

Report of a Dicephalic Steppes Ratsnake (*Elaphe dione*) Collected in South Korea

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Abstract In this report, we describe morphological characteristics of a dicephalic Steppes Ratsnake (*Elaphe dione*) collected from the wild in 2011 in South Korea. The specimen has two heads and two long necks. Unlike normal individuals, the dicephalic snake has divided ventral scales under the necks of the bifurcated columns. The snout-vent length (SVL) and overall total length of the individual are shorter than those of normal snakes of the same age. Nevertheless, the counts of nine different scale types that are often used for classification are all within the ranges of normal individuals. As far as we know, this is the first detailed morphological description of a dicephalic *E. dione* in the scientific literature.

Keywords dicephalism, morphology, Steppes Ratsnake, *Elaphe dione*

1. Introduction

Dicephalism, an individual having two heads, is a type of malformation that occurs in less than 0.5% of vertebrates (Singhal *et al.*, 2006). Although dicephalism has been reported in many different animal taxa, reports are more frequent in reptiles (Heasman, 1933; Blanc, 1979; De Albuquerque *et al.*, 2010, 2013). Dicephalism has been reported in eight families of snakes and three families of lizards (Wallach, 2007; Spadola and Insacco, 2009). Based on Wallach's review (2007), 101 dicephalic cases are known in Asia, but reports in the scientific literature containing detailed morphological descriptions are very rare (Bakken and Bakken, 1987; Petch, 1990).

The Steppes Ratsnake (*Elaphe dione*) is widely distributed, as far west to Europe and east to China, Korea, and Russia. *E. dione* can be found in various habitats including agriculture and forest areas, from latitude of sea level up to approximately 3500 m (Kang and Yoon, 1975; Schulz, 1996). In general, the total length, including the tail, of adult snakes ranges from

60 to 70 cm and rarely reaches 120 cm (Schulz, 1996). Dicephalic *E. dione* individuals have previously been recorded two times: one was shown on a TV program (Wallach, 2007) and the other was reported as a photograph in a book (Sim, 2001). However, a detailed description of a dicephalic *E. dione* does not exist in the primary scientific literature. This report describes the morphological characteristics of a dicephalic *E. dione* collected from the wild in 2011 from South Korea.

2. Materials and Methods

The dicephalic *E. dione* described in this study was found on 2 November, 2011 at the edge of an apple farm located in the middle of an agriculture area in Jukjeon-ri, Pungsan-up, Andong-si, Gyeongbuk Province, South Korea (36°38'23.9" N, 128°35'22.0" E). Low mountains surround the area approximately 400 m from the site. The altitude of the site is 246 m. Based on the total length of the specimen (Lee *et al.*, 2011), it was considered a juvenile snake born in 2011. The dicephalic snake was transported to and kept in a laboratory in Kangwon National University. To comparatively examine the dicephalic specimen, we obtained five normal *E. dione* individuals that were born in 2011 through a donation from a local snake farm approximately 150 km from

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the collecting site. Snakes were kept individually in temperature controlled vivariums ($25.7 \pm 2^\circ\text{C}$) and fed thawed, chopped, one-week old mice weekly until on 31 December, 2011 when the dicephalic individual died by unknown causes. The dicephalic individual and the five normal individuals which were euthanized under diethyl-ether anesthesia on the same day were preserved in 10% formalin after morphological examinations and stored in the laboratory.

We compared several morphological characters of the dicephalic and normal individuals. We measured head length (from the tip of snout to the quadrate-articular jaw joint), head width (at the widest point), snout-vent length (SVL, from the tip of snout to the end of the anal plate), and tail length (from the end of the anal plate to the tip of the tail). All measurements were to the nearest 0.1 mm using digital vernier calipers. Body weight was measured using a digital balance (Kern TMB 120-1, Wildeck, Germany) to the nearest 0.1 g. From the measurement data, we also calculated the total length (from the tip of snout to the tip of the tail), head length: SVL ratio, tail length: SVL ratio, and the body weight per unit of SVL. Next, we checked whether the dicephalic specimen had any specific morphological differences in relation to scale counts. We counted the number of ventral, subcaudal, dorsal (at mid-body), supralabial, infralabial, subocular, postocular, and temporal scales, as these counts are commonly used in morphological classification of *Elaphe* (Schulz, 1996). In addition, we determined how many and which supralabial scales are in contact with the eye.

In order to determine the bifurcation point of the two heads in terms of vertebrae, we took radiographs of the preserved dicephalic specimen at the Chungnam Wild Animal Rescue Center. Additionally, by dissection and direct anatomical examination we determined the sex and the status of duplicated internal organs of the dicephalic individual. In particular, we determined the location and size (longitudinal length) of the two hearts of the dicephalic individual. From these data, we calculated the ratio of heart size to SVL.

Animal handlings and investigation procedures described in this report were conducted in accordance with guidelines established by the Kangwon National University Institutional Animal Care and Use Committee.

3. Results and Discussion

Between 7 November and 28 December, we fed the snakes nine times with thawed, chopped, one-week old mice (1.7 ± 1.5 g, range = 0.87–2.34 g). We paid special

attention to the feeding behavior of the dicephalic snake. During the first two feedings, we observed competition between the heads. When we fed five pieces of meat, the left head (from the top view) ate four pieces and right head one piece, resulting in biting (11 total) between the two heads. As a result, for subsequent feedings, we taped one of mouths of the dicephalic individual to prevent biting. The body weight of the dicephalic individual increased from 4.71 g to 6.7 g during the captive period. We did not track body weight changes of the normal individuals.

Reports on feeding behavior of dicephalic snakes are very rare although it is believed that both heads independently grasp and swallow prey (Burghardt, 1991). In 1993, a study using a dicephalic Black Ratsnake (*E. o. obsoleta*) showed that competition between the two heads often occurs during feeding, and the individual cannot be satiated by feeding of only one head (Andreadis and Burghardt, 1993). High feeding competition between the two heads observed in this study suggests that each head of the dicephalic *E. dione* seeks independent satiation, supporting that oropharyngeal stimulation is involved in meal termination of snakes (Andreadis and Burghardt, 1993). In the field, such feeding competition could decrease foraging efficiency of dicephalic snakes, possibly resulting in slower growth and increased mortality.

The dicephalic *E. dione* has two heads and two long necks, which fuse at approximately one-fifth the length of the SVL (Figure 1). We refer to the two heads as the left and right column (from the top view). The lengths of the left and right columns from the tip of snout to the vertebrae fusion site are 42.6 mm and 40.8 mm, respectively. The left column exhibits a slightly longer head length, head width, SVL, and total length than



Figure 1 Photograph of the dicephalic Steppes Ratsnake (*Elaphe dione*).

the right column (Table 1). The body weight of the dicephalic snake (6.7 g) was not different compared to normal individuals of the same age (6.7 ± 2.9 g, range = 4.1–10.6 g, $n = 5$). The body weight per unit of the SVL (0.320 g/cm for the left column and 0.322 g/cm for the right column) of the dicephalic snake was slightly higher than average, but fell within the range of normal individuals (0.271 ± 0.121 g/cm, range = 0.134–0.451 g/cm, $n = 5$). Except for the head length and head width of the right column and the total length of the two sides, the other measurements of the dicephalic ratsnake are within the ranges of normal individuals (Schulz, 1996; Table 1). In addition, there was no notable difference in color pattern between the dicephalic and normal individuals.

Based on Smith and Pérez-Higareda's (1987) classification, the specimen can be categorized as a proarchodichotomous specimen that has two heads, two long necks and a single body. As in previous reports (Petch, 1990; Manimozhi *et al.*, 2006; McAllister and Wallach, 2006), the SVL and total length of the dicephalic *E. dione* were shorter than those of normal individuals. In contrast, the dicephalic *E. dione* had a slightly higher body weight per unit of the SVL compared to the average in normal individuals. This might be simply explained by the presence of two long necks and duplicated internal organs within a shorter SVL (McAllister and Wallach, 2006). As shown in this study, it has been reported that two heads of a dicephalic snake often exhibit small differences in size (McAllister and Wallach, 2006;

De Albuquerque *et al.*, 2010).

In our examination of scale morphologies, we found that each ventral scale under the bifurcated columns was longitudinally divided into two parts unlike the presence of undivided scales in normal individuals (Figure 2 C). In addition, the lateral division (compared to the medial division) was divided transversally into two pieces (Figure 2 C). The longitudinally and transversally divided scales were counted as one scale for the purpose of comparing the number of scales. The numbers of ventral and infralabial scales on the left column were more than those on the right column, but both numbers were within the ranges of normal individuals (Table 2). The numbers of other scales (subcaudal, dorsal, supralabial, subocular, postocular, and temporal scales) were the same on the two columns and all were within the normal ranges (Table 2).

The divided ventral scales reveal the possibility that dicephalic development affects scale development and morphology. Such divided ventral scales in dicephalic snake have also been reported in a dicephalic anaconda snake (*Eunectes notaeus*, De Albuquerque *et al.*, 2010). The anaconda snake had several, not all, divided ventral scales on the bifurcated columns. In our study, the numbers of scales on different heads and body are within normal ranges, although the SVL of the dicephalic snake is smaller than those of normal individuals. This result is consistent with a previous finding in a dicephalic western Diamondback Rattlesnake (*Crotalus atrox*, McAllister and Wallach, 2006) suggesting that the dicephalic process

Table 1 Measurements of the dicephalic and normal Steppes Ratsnakes (*Elaphe dione*). Data for normal snakes are in the form of: mean \pm SD (range) (unit: mm).

Specimen	Head length	Head width	SVL	Tail length	Total length	Head length/SVL	Tail length/SVL
Dicephalic snake left column	13.1	6.2	209.4	52.3	274.8	0.06	0.25
Dicephalic snake right column	12.5	5.9	207.7	52.3	272.5	0.06	0.25
Normal snake ($n = 5$)	14.2 ± 1.3 (13.0–16.1)	6.2 ± 0.2 (6.0–6.5)	244.8 ± 39.0 (207.7–306.9)	56.9 ± 9.7 (49.7–65.9)	324.5 ± 49.1 (284.7–388.9)	0.06 ± 0.00 (0.05–0.06)	0.23 ± 0.02 (0.21–0.26)

Table 2 Comparison of scale counts on the head and body between the dicephalic and normal Steppes Ratsnakes (*Elaphe dione*). “Supralabial contacting eye” indicates both how many and which supralabial scales contact the eye. Schulz (1996) represents the data for 45 normal Steppes Ratsnakes collected from England, Germany, and Netherlands. Data are in the form of: mean \pm SD (range).

Specimen	Ventral	Subcaudal	Dorsal	Supralabial	Supralabial contacting eye	Infralabial	Subocular	Postocular	Temporal
Dicephalic snake left column	190	66	24	8	2 (4, 5)	11	1	2	2 + 3
Dicephalic snake right column	186	66	24	8	2 (4, 5)	10	1	2	2 + 3
Normal snake ($n = 5$)	196.2 ± 11.9 (180–208)	69.2 ± 4.6 (65–75)	24.6 ± 0.5 (24–25)	8.2 ± 0.4 (8–9)	2 (4, 5 or 5, 6)	11	1	2	2 + 3 or 2 + 4
Schulz (1996)	170–214	55–80	23–27	8(7, 9)	2 (4, 5 or 5, 6)	10–12	1	2–3	2 + 3 or 2 + 4

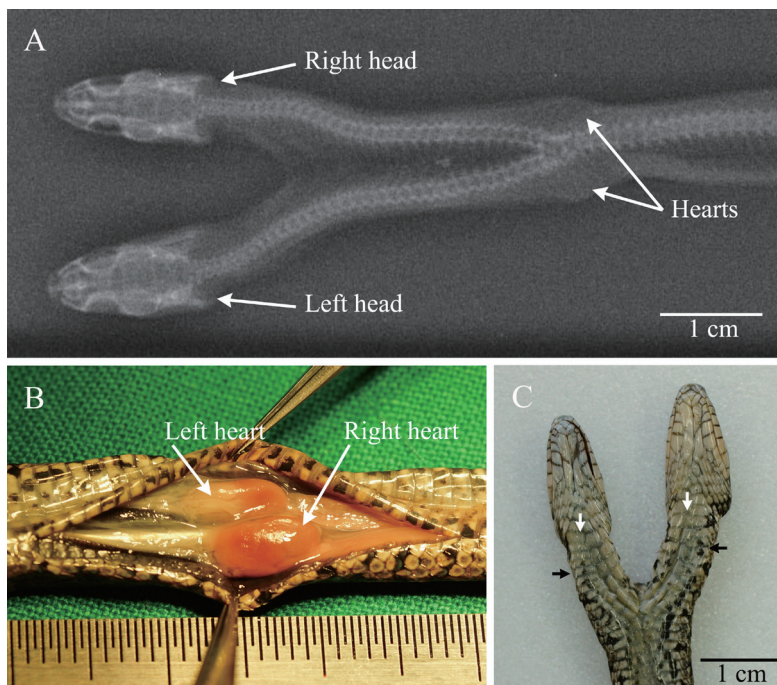


Figure 2 The dicephalic Steppes Ratsnake (*Elaphe dione*) in detail. A: Radiograph of the dicephalic *E. dione*; B: Anatomical view of the duplicated hearts; C: Unusually divided ventral scales under the bifurcated columns. Longitudinal and transversal divisions are indicated by the white and black arrows, respectively.

might not affect the number of scales.

In radiographs, the left column of the dicephalic *E. dione* had 33 vertebrae and the right column had 31 vertebrae before fusion into a single vertebral column (Figure 2 A). The most internal organs such as lung, liver, kidney, and intestine of the dicephalic individual were normal, but the heart was duplicated and located at just below the point of vertebrae fusion (Figures 2 A, B). The left heart (6.16 mm) was smaller than the right heart (7.01 mm), and both hearts were smaller than those of normal individuals (9.29 ± 1.46 mm, range 7.60–11.50 mm, $n = 5$). The ratio of heart length to SVL was also smaller in the dicephalic individual (0.029 for the left column, 0.034 for the right column) than in normal individuals (0.037 ± 0.003 , range 0.033–0.041, $n = 5$). Esophagi from the bifurcated columns were fused at approximately 0.5 cm above the duplicated hearts and two aortas from the two hearts were combined into one blood vessel at approximately 0.7 cm below the hearts. The dicephalic individual did not have hemipenes so it was identified as a female.

In general, dicephalic snakes have duplicated organs and glands, although some viscera such as the gonads, adrenals, kidneys, and large intestine, which are relatively caudally located, are not duplicated (McAllister and Wallach, 2006). The duplicated hearts observed in this study are consistent with this pattern. The dicephalic

individual has smaller hearts than normal individuals simply due to the presence of two hearts instead of one, as shown in Heasman (1933). In this study, the right heart was bigger than the left heart, although the left column of the dicephalic snake was longer than the right column. The bigger heart in the smaller right column might be caused by growth of the heart in compensation for low efficiency of the circulatory system in the right column, but detailed causations underlying the physical and internal organ size differences in dicephalic snakes are unknown.

In summary, we, for the first time, describe the detailed morphological characteristics of a naturally occurring dicephalic *E. dione* collected from South Korea in 2011. Considering that scientific reports on dicephalic reptiles are particularly rare in Asia, detailed morphological and anatomical data should be documented in a scientific literature when additional dicephalic snakes are found.

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